Angler Use and Abundance of Stocked 229-mm Channel Catfish in Twenty Small Texas Impoundments

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ABSTRACT

Sub-adult channel catfish (Ictalurus punctatus) are stocked into community fishing lakes in Texas to provide anglers with the opportunity to catch fish close to home. Survival of these stocked fish is unknown, and this study was initiated to provide some information and guidance for the Texas Parks and Wildlife Department channel catfish stocking program. The initial study was conducted on 20 lakes in Texas between 0.4 and 4.0 ha, with 10 located in urban environments and the other 10 in rural locations. A follow-up investigation was conducted on a subset of 16 of the lakes. Lakes were stocked one time with adipose or pelvic fin-clipped channel catfish and surveyed with baited hoop nets for 6 months. Angler effort was estimated using game cameras and a short-term creel survey. Urban angling effort was significantly higher than rural angling effort. Winter had the lowest angling effort and angling effort declined significantly two weeks following stocking. Hoop-net catch rate was similar between urban and rural lakes and for spring and fall stocked fish. Hoop-net sampling in 25% of fall-stocked lakes and 12.5% of spring-stocked lakes yielded no recaptures of stocked channel catfish and stocked fish essentially disappeared within four months of stocking in another 25% of all lakes. Angling effort was lowest on lakes where stocked fish survived all six months; fishing effort was highest on lakes where stocked fish disappeared in <6 months, indicating probable angler harvest though documented harvest was low. Angling effort on lakes where no channel catfish survived was intermediate. The 229-mm channel catfish stocking program provided angler opportunity for at least six months in 50% of the stocked lakes and for less than six months in another 25%. Based on the results of this study, all lakes in the channel catfish stocking program should be evaluated for stocking success, and those characterized as unsuccessful should be removed from the program.

INTRODUCTION

Put-and-take fisheries, where catchable-sized fish are stocked and immediately available to anglers, are commonly used to provide increased fishing opportunities. One of the challenges of the put-and-take model is deciding how to partition limited resources (stocked fish) to provide the greatest benefit to the most anglers. Stocking the appropriate number of fish is important for making efficient use of the fish and creating desirable fisheries (Michaletz 2009). If too few fish are stocked, the likelihood of catch may be so low that few anglers will participate (Alcorn 1981, Miko et al. 1995, Wickham et al. 2004). Understanding how anglers respond to stockings is crucial to assessing the benefit of these programs. Because the most influential factor determining whether or not someone fishes is if there are opportunities close to home (Patterson and Sullivan 2013), one strategy managers often use is to distribute the stocked fish to numerous water bodies to benefit many local anglers.

The Texas Parks and Wildlife Department (TPWD) stocks advanced fingerling channel catfish (Ictalurus punctatus) as a cost-effective way of providing fish to the angling public (Eder and McDannold 1987, Michaletz and Dillard 1999, Michaletz et al. 2008, Munger 2012). Stocking catchable-size channel catfish incurs a substantial investment of time and money for production and delivery. For instance, TPWD stocked catchable-sized (i.e. approximately 229-mm total length [TL]) channel catfish into about 250 community fishing lakes (CFLs) each year in 2013 and 2014 at a cost of US$344,091 (112,642 fish) in 2013 and $684,623 (185,571 fish) in 2014 (T. Engeling, TPWD, personal communication). Thus, it is important that this program be operated as efficiently as possible to maximize benefits to anglers while minimizing costs.

The CFL channel catfish stocking program of TPWD is based on a simple put-and-take concept that assumes stocking catchable-size fish will immediately create a fishery that attracts anglers and that stocking higher numbers of fish will attract even more anglers. This concept further assumes that anglers will catch most of the fish and that angler catch rates affect the perception of the fishery by the angler (Patterson and Sullivan 2013). Given the small size (<5 ha) of most Texas CFLs and the simple morphology of these systems, it is assumed that an angler’s likelihood of catching a channel catfish is greater than would be expected in larger, more complex systems. This put-and-take strategy is an important element, as both Munger (2012) and Siegwarth and Johnson (1998) determined that stocked channel catfish composed over 90% of the total channel catfish population in small impoundments.

Even when sufficient numbers of fish are initially stocked, if survival of these stocked fish is low then angling opportunity will be diminished. High survival of stocked fish over time will extend their availability to anglers and presumably the opportunity to catch fish. Survival of channel catfish in small impoundments appears to be highly variable and has both natural and angling components. Natural mortality of stocked channel catfish was reported to be high (i.e., 55% during their first year; Storck and Newman 1988), very low (i.e., <7%; Santucci et al. 1994), and highly variable (Munger 2012). Likewise, angler harvest of channel catfish in Alabama small impoundments was found to be highly variable, ranging from 0.99 to 767.90 fish/ha (Shaner et al. 1996); whereas, Santucci et al. (1994) reported high angler harvest in Illinois lakes, with 52%-92% of stocked channel catfish >200 mm TL being harvested within one year. The size and number of stocked channel catfish can impact post-stocking survival of fish which often relates to the relative success of the put-and-take stocking strategy (Eder and McDannold 1987, Shaner et al. 1996). Stocking channel catfish longer than 200 mm TL results in increased survival (Storck and Newman 1988, Howell and Betsill 1999) and return to anglers (Storck and Newman 1988). Therefore, it is important to understand not only how anglers respond to stocking, but how long fish are available to anglers.

For Texas, one major challenge is how to partition resources between rural and urban anglers. While human population densities are higher in urban areas, fishing effort may not be correlated with that density. Munger (2012) reported that angling pressure was similar on an urban CFL (913.6 h/month) and a rural CFL (932.1 h/month). Chizinski (2012) expected higher exploitation in lakes located near human population centers or easily accessed state recreation areas, but that relationship was not always reflected in creel surveys. Further, angler motivations may differ, altering the overall survival of stocked fish. Surveys conducted more than thirty years ago showed that urban anglers were more likely to be interested in harvest than recreation (Alcorn 1981, Ditton and Fedler 1984, Manfredo et al. 1984) but more recent studies indicate a higher percentage focused on the recreational and social aspect of fishing rather than harvest (Schramm and Dennis 1993, Hutt and Jackson 2008, Mahasuweerachai et al. 2010). Angler behavior may be different even among lakes that would be categorized as rural. Anglers who fished Pony Express Lake, Missouri, released very few of their catfish (Eder and McDannold 1987); whereas, all catfish caught at Canyon Southeast Park Lake, Texas, were released (Munger 2012). Understanding the differences in effort between urban and rural sites may allow fisheries managers to better allocate stocked channel catfish.

The goal of this study was to verify the assumption that the TPWD CFL channel catfish stocking program is providing opportunity to catch channel catfish for anglers using these fisheries. The original investigation segment was conducted on 20 small CFLs in both urban and rural settings throughout Texas. A follow-up investigation was conducted on 16 of the lakes using spring stocking. The specific objectives of these studies were to 1) estimate angler effort associated with stocked channel catfish in CFLs, 2) test whether angler use differs between rural and urban settings, and 3) estimate how long stocked channel catfish are available to anglers in the CFLs. For the purposes of this study, any documented population of channel catfish remaining more than six months after stocking was deemed a successful stocking. The results of this study will provide baseline data on stocked channel catfish survival in a variety of CFLs across Texas, information on angler use of the resource, and inform TPWD concerning future stocking and management of CFLs.

METHODS

Fall Stocking Study Sites and Stocking Procedures

The initial study was conducted on 20 CFLs between 0.4 and 4.0 ha distributed throughout Texas. Ten of the lakes were located in urban environments and the other 10 in rural locations. We considered an urban environment to be equivalent to the U. S. Census Bureau definition of a metropolitan area, with a core urban area population ≥50,000, within one or more counties, and any adjacent areas that have a high degree of social and economic integration. A rural lake was defined as being located anywhere that is not an urban area.

Each lake was stocked with adipose fin-clipped (McFarlane et al. 1990) channel catfish in late October or early November 2013. The short time frame for this study and complete removal of the fin reduced the risk of regrowth of the adipose fin in instances where removal was not complete (Wydoski and Emery 1983, Nielsen 1992). Because we were evaluating success of the normal CFL channel catfish stocking conducted by TPWD, this study used the normal TPWD stocking request process and formula, and standard stocking procedures. Stocking rates were determined by a log-linear equation used by TPWD to determine CFL channel catfish stocking rates: $N = 400A^{-0.70874}$, where A was the surface area of the lake in acres and N was the number of fish stocked per acre. Thus, stocking rates for lakes in this study decreased from 988 fish/ha to 249 fish/ha as CFL area increased from 0.4 to 4.0 ha. Study fish were fin clipped by TPWD staff as they were sorted in raceways prior to stocking, and stocking was conducted according to standard TPWD procedures.

Angler Data

Angler counts were conducted using digital game cameras with methods patterned after those described in Patterson and Sullivan (2013). Cameras were placed in secure locations near each lake, close enough to accurately observe angling activity and covering as much of the lake as possible. If multiple cameras were used on a lake, efforts were made to minimize overlap of photographs to reduce the risk of double-counting anglers. When multiple cameras were used, counts from all cameras were combined to develop a single angler count for each hour.

Game cameras were programmed to record images once every hour from daylight to dark. Hunt and Ditton (1996) determined that most fishing trips to CFLs in Texas lasted 4 h, so the 1-h photo interval should have been sufficient to allow estimation of angler use of the resource. The number of daily counts and start times for each daily count were derived from the TPWD standard creel survey day-length table (TPWD unpublished survey procedures). Photo recording began approximately one week prior to stocking and continued through 31 August 2014. Photographs were reviewed each month by district staff and the total number of anglers fishing each hour of each day was recorded as an estimate of angler effort for that hour. If an angler was counted within an hour, that angler was counted as fishing for one full hour. Angler counts for each lake were summed by hour, day, and month as estimates of angling effort for each time period.

Total angling effort (angler-h) was estimated at each lake and used to evaluate differences between urban and rural lakes and to see if effort changed relative to the stocking event and season. Seasons were defined as winter (December-February), spring (March-May), summer (June-August), and fall (September-November). Fall data were not analyzed further due to low sample sizes. To test differences in angling effort among lake type and season, ANOVA-type statistics were performed using package nparLD in R software (Kimihiro et al. 2012). A post hoc Pairwise Wilcox test with a Bonferroni correction was used to identify the differences reported in the nparLD ANOVA procedure.

Stocking effect on angling was determined by ANOVA using average angler counts for stocking weeks and post-stocking weeks. Stocking weeks were the first full week following stocking and the week immediately following. Post-stocking weeks were defined as the 4^{th} and 5^{th} weeks after the actual stocking week.

Hoop Net Data

Abundance data for stocked channel catfish were collected using baited, small-diameter hoop nets. Hoop-net surveys commenced two weeks following the initial stocking and were conducted monthly through May 2014. Hoop nets are commonly used to collect channel catfish in lakes (Sullivan and Gale 1999, Michaletz and Sullivan 2002, Flammang and Schultz 2007, Buckmeier and Schlechte 2009). Baited hoop nets are more efficient in small lakes (Wallace et al. 2011, Chizinski 2012) and have been shown to sample channel catfish in proportion to their abundance without size bias (Yeh 1977, Buckmeier and Schlechte 2009).

Hoop nets used in this study had five, 61-cm inside diameter fiberglass hoops with throats tied to the first and third hoops, were approximately 3 m long, and constructed of 2.54-cm bar mesh (Munger 2012). Hoop nets were fished as sets of three nets tied in tandem (Walker et al. 1994, Sullivan and Gale 1999, Michaletz and Sullivan 2002, Flammang and Schultz 2007, Wallace et al. 2011). The three nets were connected mouth to cod end with approximately 1 m of lead between adjacent nets and considered a single unit of effort.

Hoop nets were fished undisturbed for two consecutive nights as described in Neely and Dumont (2011). Each hoop net was baited with approximately one third of a commercially available cheese log (Gerhardt and Hubert 1989), which was placed in a mesh bag and attached to the hoop nearest the cod end of each net. The small size of study lakes limited the possible number of random sampling locations, so fixed sampling sites were used. Since sampling was conducted on urban lakes where human interference was expected to occur, all sampling locations were selected to reduce possible incidence of snagging by anglers and nets were set in water at least 1.5 m deep. Evidence of high traffic along shoreline areas was used to determine locations that should be avoided. Net floats were designed to be inconspicuous to reduce disturbance by anglers or other lake users.

Each lake was sampled with two hoop-net sets, at 1-month intervals beginning within two weeks of stocking and continuing through May 2014. Channel catfish data were combined from all three nets in the set and recorded as total catch/net-set. All channel catfish were counted, inspected for fin clips, measured (TL, mm), weighed (g), and then returned to the lake.

Hoop-net catch-per-unit-effort (CPUE) was calculated for each lake by month and used to indicate channel catfish availability to area anglers. Flammang and Schultz (2007) showed that catch across seasons was similar within impoundments and therefore we considered it to provide an indicator of persistence in the CFL. Catch rates were calculated by averaging the CPUE of the two sets per sample. The relationship between hoop-net CPUE and angler effort and hoop-net CPUE and stocking rate was tested using correlation analysis. Differences in hoop-net CPUE by lake type were tested using ANOVA. A significance level of $P \leq 0.05$ was used for all tests. Statistics were calculated with program R and SAS plug-in for Excel. Outlier lakes for angler-count or hoop-net data were identified using the extreme studentized deviate test (Grubb 1969), and if found, were removed from analyses of that particular dataset.

Stocking Success

Lakes were assigned to three stocking success categories. Lakes where no stocked channel catfish were recaptured were categorized as unsuccessful. Lakes where marked channel catfish were initially recaptured but were no longer captured after six months were placed into a partial success group. Lakes where stocked channel catfish were recaptured throughout the sampling period were considered successful. Mean stocking rate, angler effort, and hoop-net catch rate were examined across these categories with ANOVA, as described earlier. Post hoc Bonferroni (Dunn) t-tests for Count were conducted on angler effort by stocking success category, and mean hoop-net catch rate was examined through time among success categories.

Spring Stocking Evaluation

The follow-up spring stocking study was conducted on 16 of the CFLs used in the original investigation. Nine of the lakes were in urban areas and 7 were in rural areas. Most of the procedures were identical to the initial fall stocking investigation, but there were some modifications. Each lake was stocked with pelvic fin-clipped channel catfish in March 2015. Three creel surveys were conducted during the spring investigation in lieu of game cameras. The initial creel was conducted two hours following stocking, on the day of stocking. Creels were also conducted at 1400 hours on the first Saturday following stocking and at 1800 hours on the first Tuesday following stocking. The protocol consisted of an instantaneous angler count at the start time followed immediately by a roving creel survey. The creel clerk would walk a circuit around the site and interview each angler. Fish in possession of the angler at the time of the interview were considered harvested. The creel survey was complete after one lap of the CFL.

Creel data were analyzed to estimate three-day fishing effort, and catch and harvest of marked and unmarked fish. Marked fish included both the adipose-clipped fish from the fall stocking investigation and the pelvic-clipped fish from the spring investigation. Effort and harvest rates were used to estimate total harvest for the three creel days.

Hoop netting was conducted as described in the fall stocking procedures except that spring-stocked channel catfish were allowed to acclimate in the lake for two weeks prior to commencement of the hoop net surveys. Only three hoop net surveys were conducted with the first occurring 2-3 weeks following stocking (April) and the other two in June and August. ANOVA was used to compare hoop net catch rates of spring-stocked and fall-stocked fish overall and between urban and rural sites. Mean CPUE was used for hoop net catch trends over time for all data and for urban and rural CFLs. Stocking rate and its relationship to hoop net CPUE was also evaluated via ANOVA. Significance level was set at $P \leq 0.05$.

RESULTS

Angler Data – Fall Game Camera

One urban lake was removed from angler-count analysis due to camera problems and another was determined to be an outlier and removed from the angler analysis. A total of 16,722 angler h were recorded at 18 CFLs between 30 September 2013 and 31 August 2014 with 11,068 h occurring on urban lakes (Table 1). Angler effort was consistently higher on urban lakes than rural lakes throughout the study (Figure 1), and overall mean effort was likewise higher on urban lakes (F = 5.55, df = 1, P = 0.02) (Table 1). Angler effort was lower in winter than in spring or summer (F = 33.65, df = 1.85, P < 0.01) (Table 2), and no significant interactions were observed between lake type and season (F = 0.79, df = 1.85, P = 0.44). Seasonal pressure on urban lakes peaked during spring, whereas effort on rural lakes peaked in summer (Table 2). Angler effort during stocking weeks (Figure 2) was significantly higher than post-stocking weeks for all lakes combined (F = 65.12, df = 3, P = 0.02) and for urban lakes (F = 237.32, df = 3, P = 0.04), but not for rural lakes (F = 2.47, df = 3, P = 0.26). There was no significant relationship between stocking rate and average angling effort (F = 2.28, df = 35, P = 0.14).

Angler Data – Spring Creel

A total of 55 anglers were interviewed during the three spring creel surveys and they had fished a total of 62 hours (Table 3). They were observed to harvest 21 pelvic-clipped channel catfish and release 31. No unmarked channel catfish were observed in the creels. The average harvest rate of marked channel catfish was 0.10/h and the average total catch rate of marked fish was estimated at 0.48/h. Nine of the lakes had no channel catfish catch or harvest observed, seven had anglers reporting catch and release and three had observed harvest. Harvest rates observed in those three lakes were 0.15, 0.15 and 1.33 marked fish/h, respectively. An average of 1.9 fish/lake were caught and released over the three creel days (range 0-11/day), for an average of 0.63 channel catfish caught and released per day.

Hoop Net Data – Fall Stocking

Hoop-net CPUE was 4.6 fish/net-set (SD = 10.7) across all lakes (Table 4). Hoop-net CPUE was 2.5 fish/net-set (SD = 6.0) and 6.8 fish/net-set (SD = 13.9) for urban and rural lakes, respectively; these were not significantly different (F = 1.14, df = 19, P = 0.30). Five lakes had no recaptures of stocked fish. When those lakes were removed from analysis, the urban average CPUE was 2.7 fish/net-set (SD = 6.2) and the rural average CPUE became 10.3 fish/net-set (SD = 16.0). There was no correlation between stocking rate and hoop-net CPUE (r^2 = 0.02, P = 0.52) or between hoop-net CPUE and angler effort for all lakes combined (r^2 < 0.01, P = 0.79), urban lakes (r^2 = 0.02, P = 0.75) or rural lakes (r^2 < 0.01, P = 0.81). There were no correlations among stocking rate, hoop net catch, or angler effort across lakes or lake type (all P > 0.5).

Hoop Net Data – Spring Stocking

Hoop-net CPUE for spring stocking over the six months averaged 11.9 fish/net-set (SD = 16.7) across the 16 lakes (Table 5). Abernathy Lake had an extremely high CPUE in August (56.5 fish/net-set), which greatly skewed the average and was deemed an outlier. When this lake was removed from the average calculation, the hoop-net CPUE for 15 lakes was 8.6 fish/net-set (SD = 11.1). Abernathy Lake hoop net data was removed from further catch rate analysis. Spring stocking hoop-net CPUE was 1.6 fish/net-set (SD = 2.2) and 4.9 fish/net-set (SD = 16.2) for urban and rural lakes, respectively, but were not significantly different (F = 1.99, df = 5, P = 0.23). There was also no significant difference in hoop-net CPUE between spring and fall stocking (F = 0.86, df = 5, P = 0.40). Two of the lakes had no recaptures of stocked fish. When those lakes were removed from analysis, the rural average CPUE became 17.5 fish/net-set (SD = 16.3) and the urban average CPUE 5.3 fish/net-set (SD = 1.5). There was no correlation between stocking rate and hoop-net CPUE (r^2 = 0.07, P = 0.93). Fish with adipose marks from the fall-stocking investigation were collected in low numbers in five of the surveyed lakes.

Stocking Success – Fall Stocking

Channel catfish stocked in the fall were never recaptured in four rural lakes and one urban lake and stocking was considered unsuccessful (Table 4). Stocking was partially successful in two rural and three urban lakes. Channel catfish were recaptured throughout the 6-month sampling period in the remaining ten lakes (four rural and six urban). Mean stocking rate did not vary across stocking success categories ($F = 0.54$, df = 17, $P = 0.59$).

Analysis of angling effort showed significant differences among success categories (Table 6). Angling effort in the partial success group (mean, 30.6 h/week, SD = 22.3) was similar to what was observed in the unsuccessful group (mean, 22.7 h/week, SD = 15.8) but was higher than effort in the success group (mean, 15.8 h/week, SD = 11.5; $F = 8.65$, df = 135, $P < 0.01$). For all lake types, it was observed that abundance of stocked channel catfish declined through time (Figure 3). Mean hoop-net CPUE in the partial success group declined from a group average of 16.1/set (SD = 19.2) in November to 0.6/set (SD = 0.8) by January. Five of 10 lakes in the success group had either stable or increasing CPUE of stocked channel catfish, while the other five showed declining CPUE.

Stocking Success – Spring Stocking

Channel catfish stocked in the spring were never recaptured in two lakes, one rural and one urban (Table 5), and the stockings were considered unsuccessful. Stocking was partially successful in two rural and two urban lakes. Channel catfish were recaptured throughout the 6-month sampling period in the remaining ten lakes (four rural and six urban).

For all lake types, it was observed that abundance of stocked channel catfish declined through time, similar to fall stocking (Figure 4). Mean hoop-net CPUE in the partial success group declined from a group average of 3.1/set (SD = 2.7) in April to 0.0/set by August. All 10 lakes in the success group had either similar or increasing CPUE of stocked channel catfish through the investigation period.

DISCUSSION

Stocking events can directly affect the behavior of anglers, resulting in increased effort and harvest immediately following stocking. Alcorn (1981) found that fluctuations in the number of fish caught was closely related to fish stocking dates with the highest catch rates observed for only a few days following stocking. Howell et al. (2008) reported that 25% of stocked fish were harvested within six days of stocking and that there was high angling pressure for a few days post stocking followed by a 50%-70% decline in angling effort within a week. Similarly, angling effort in the first two full weeks following stocking in Texas CFLs was higher than effort during the fourth and fifth weeks after stocking, for all lakes combined and urban lakes, but not for rural lakes. On average, only 1.1 anglers/day were observed in creel surveys at the CFLs and these anglers were observed to harvest very few stocked fish. Harvest was only observed on three of the lakes and the highest estimated three-day harvest was 17 fish representing 3.4% of the stocked fish. The other two lakes had less than 0.5% of the stocked fish harvested over the three days. At these harvest rates, the quickest a stocked population could be removed would be 451 days (1.1%/day) with most, theoretically, lasting over 1,200 days.

When channel catfish are stocked into a CFL, the objective is to provide anglers an opportunity to catch fish. Thus the fate of stocked fish in these lakes directly impacts amount of fishing opportunity provided to the anglers. The stated definition of a successful stocking within this study was to have at least some of the fish still available to anglers six months after stocking. Stocked channel catfish disappeared soon after stocking in 12.5-25.0% of the study lakes, and survived for less than the target six-month period in another 25% of the lakes. Thus, the program was successful in meeting its stated six-month goal in only 50% of the study lakes, for both spring and fall stocking investigations. Hoop-net data from these successfully-stocked lakes indicated that, on average, approximately 60% of the stocked channel catfish remained in the lake at the end of six months. Half of the lakes deemed successful in the spring investigation still had channel catfish marked with the adipose-fin clip from the fall investigation indicating long-term stocking success in at least 25% of study CFLs. Classification of lakes by stocking success does seem to have some validity. When classifications of individual lakes were compared, for fall and spring investigations, they were very similar. Most of the changes involved a move of just one classification (e.g., partial to successful). Two lakes changed from partial to successful, two changed from partial to unsuccessful, one changed from unsuccessful to partial, and one changed from successful to partial (Table 7). Two of the study lakes changed from unsuccessful in the fall study to successful in the spring study. There were no lakes that changed from successful to unsuccessful.

The rapid disappearance of stocked channel catfish from CFLs may be due to harvest and not natural mortality, but based on both creel data and game camera angler counts, it appears unlikely. Obviously, if the fish are being lost to harvest, then the goals of providing angling opportunity are still being met. Anglers that use urban fishing lakes are often described as being more harvest oriented (Alcorn 1981, Manfredo et al. 1984), but Munger (2012) found that anglers did not harvest any channel catfish in two Texas urban CFLs. Michaletz and Stanovick (2005) stated that angler harvest of channel catfish increased with angling effort, so higher angler counts determined by game cameras could be assumed to represent higher harvest by anglers. Data from the spring investigation creel indicate that channel catfish harvest in Texas CFLs is very low and that anglers cannot be assumed to be harvesting channel catfish from CFLs. Mean and maximum weekly angler effort was higher on partial-success CFLs than succussful CFLs, but effort in the unsuccessful CFLs was intermediate and similar to the other types. Further, stocked channel catfish disappeared immediately in all of the unsuccessful lakes and disappeared within four months after stocking in 40% of the partial success lakes during seasons when angler effort was the lowest. While Alcorn (1981) and Howell et al. (2008) found that stocked fish can be quickly removed, Michaletz and Stanovick (2005) related harvest with angling effort, thus lower angler counts should indicate low harvest. Michaletz et al. (2008) found that just a few anglers can be a major source of exploitation in small impoundments, so the few anglers we observed at some of the CFLs could have had a large impact on the channel catfish population but creel data from this study does not support the idea that anglers are the main source of channel catfish loss from CFLs. Further study will be needed to determine if the fish are actually being removed by anglers or by some other type of mortality.

Management Implications

Results from this study were used to evaluate whether the CFL channel catfish fall-stocking program is meeting TPWD goals by providing sustained angler opportunity. Experimental stocking of channel catfish in spring was also evaluated. It was determined that spring stocking provided no improvement in channel catfish persistence in these lakes and therefore was not an acceptable option, considering increased hatchery costs and pond space issues. Based on the information obtained in this study the authors make the following recommendations regarding the CFL channel catfish stocking program:

1) Continue the CFL channel catfish stocking program. Fisheries management agencies are interested in increasing their user base of annual fishing license buyers and stocking can be used as a proactive tool to attract new anglers (Martin and Pope 2011). If anglers are attracted to a lake by stocking, they may then be more likely to continue to purchase a fishing license. Stocking can also be used to manage angler expectations and encourage use regardless of angling success and could improve angler attitudes about the resource and management agency (Buynak et al. 1999). This study indicated that stocked channel catfish had enough survival in 50% of CFLs to provide fishing opportunity for at least six months post stocking. Additionally, channel catfish stocking survival (from fall stocking, measured in spring) was high enough in another 25% of CFL to provide long-term opportunities.
2) Conduct follow-up survival evaluations. Since 25% of the stocked lakes showed no survival and a few others were borderline between partial and unsuccessful, stocking events should be evaluated to determine the appropriateness of stocking. The evaluation should provide reliable survival information. A single instance of an angler catching a single fish would not be considered documentation of sufficient survival. Evaluations would include appropriate fish capture techniques with a reasonable expectation of collecting a representative sample of the population. If the evaluation indicates the stocking was not successful (as defined earlier), then the CFL would be removed from the program for at least 10 years. The stocking for that CFL would be put back into available Channel Catfish for stocking. All CFLs would be re-evaluated on a periodic basis of at least every 10 years.
3) Modify the request criteria and stocking rate calculation. Modifying the stocking request criteria by including an exploratory stocking category. This category would be used to place CFLs onto the stocking list for evaluation as described in 2) above. An exploratory request may be used for a 2-3 year period during evaluation. This study found no correlation between stocking rate and hoop-net CPUE or angler effort, similar to what has been observed in other studies (Miko et al. 1995, Michaletz and Stanovick 2005). Based on this information, the log-linear stocking rate equation does not provide biologically sound stocking rates. The equation could be modified to standard stocking rates based on lake size, past stocking success, or documented angler harvest rates.
4) Evaluate channel catfish hatchery strains. Genetic strain of stocked fish can sometimes dictate survival (Yule et al. 2000). Texas hatcheries rely primarily on the imperial strain of channel catfish which was developed in 1977 in Uvalde, Texas (Dunham and Smitherman 1984). Dumont (2005) found that this strain did not outperform wild-caught offspring in reservoirs, and in some situations the wild-caught offspring appeared to be healthier. The potential that a different strain of channel catfish may survive better under conditions typically seen in Texas CFLs should be investigated. Brood stock obtained from CFLs across a wide geographic range with channel catfish, and that have been rarely stocked, may provide a genetic variation that would improve survival under the conditions seen in these lakes.

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TABLE 1.—Total angler hours, mean monthly angling effort, standard deviation, and range of monthly angling effort, by lake type for 18 community fishing lakes in Texas from October 2013 – May 2014. Means with the same superscript were similar (Pairwise Wilcox test with a Bonferroni correction, $P > 0.05$).

Type	n	Total angler h	Mean effort (angler h)	SD	Range (angler h)
All lakes	18	16,722	91.4	128.8	0-1029
Urban lakes	9	11,068	119.5^{A}	151.87	7-1029
Rural lakes	9	5654	62.8^{B}	92.03	0-484

TABLE 2.—Mean and standard deviation of angling effort (angler-hours) by season and lake type for 18 community fishing lakes (9 urban and 9 rural) in Texas from October 2013 – May 2014. Means with the same superscript were similar within the same lake type (Pairwise Wilcox test with a Bonferroni correction, $P > 0.05$; Fall was not analyzed due to incomplete data and small sample size).

Type	Fall (Oct-Nov)	Winter (Dec-Feb)	Spring (Mar-May)	Summer (Jun-Aug)
All lakes	88.7 (196.6)	30.0^{A} (26.9)	124.4^{B} (138.3)	122.2^{B} (119.3)
Urban lakes	133.6 (262.3)	41.4^{A} (27.5)	171.6^{B} (157.9)	137.8^{B} (113.7)
Rural lakes	36.4 (30.9)	18.1^{A} (20.7)	77.1^{B} (97.0)	106.6^{B} (124.8)

TABLE 3.—Spring creel summary data collected from study lakes over three creel periods in spring, 2015. Anglers, angler-hours, harvest, and catch-and-release (“Release”) are the three day totals for each value. Harvest rate is the number of fish harvested divided by total angler hours. Catch rate is the sum of harvest and catch-and-release, divided by total angler hours.

Name	Type	Three-day Totals				Harvest	Catch
		Anglers	Angler-Hours	Harvest	Release	rate (N/h)	rate (N/h)
Abernathy	Rural	9	20	3	11	0.15	0.7
Atlanta	Rural	3	12.75	17	6	1.33	1.80
Davidson	Rural	3	2	0	6	0	3
Karrh	Rural	0	0	0	0	0	0
Knierim	Rural	1	0	0	0	0	0
Little Chocolate	Rural	0	0	0	0	0	0
Winchester	Rural	8	1.5	0	1	0	0.67
Bethany	Urban	4	1.09	0	0	0	0
Cal Young	Urban	1	0.16	0	0	0	0
Cy Miller	Urban	4	2.25	0	0	0	0
Harvey	Urban	5	5.08	0	0	0	0
Houston-Harte	Urban	0	0	0	0	0	0
Huneke	Urban	7	4	0	2	0	0.50
Kennedale	Urban	5	6.57	1	1	0.15	0.30
Optimist	Urban	4	6	0	4	0	0.67
Russell Creek	Urban	1	0.6	0	0	0	0
Total		55	62	21	31	1.64	7.64
Overall Average		3.4	3.9	1.3	1.9	0.10	0.48
Rural Average		3.4	5.2	2.9	3.4	0.2	0.9
Urban Average		3.4	2.9	0.1	0.8	0.0	0.2

TABLE 4. —Name, type, surface area, channel catfish stocking rate, mean hoop-net catch-per-unit-effort (CPUE), and percentage of catfish caught in hoop nets that were stocked for 20 community fishing lakes in Texas from October 2013 – May 2014.

Name	Type	ha	Stocking rate (fish ha^{-1})	CPUE (SD) (fish net-set^{-1})	% Stocked
Abernathy	Rural	1.6	374.7	10.1 (14.06)	87.1
Davidson	Rural	0.8	606.2	0.6 (0.61)	53.8
Frio	Rural	1.5	1108.5	0.8 (0.71)	42.9
Lester	Rural	0.8	1225.7	0.2 (0.26)	100.0
Little Chocolate	Rural	1.6	374.1	14.1 (10.29)	78.5
Winchester	Rural	1.0	605.4	35.6 (18.84)	100.0
Atlanta	Rural	0.8	614.8	0.0	
Karrh	Rural	0.4	990.1	0.0	
Bridge Bob's	Rural	0.5	604.9	0.0	
Knierim	Rural	1.2	473.3	0.0	
Bethany	Urban	1.2	454.3	1.3 (1.94)	34.7
Cal Young	Urban	2.4	277.4	0.3 (0.39)	14.7
Cy Miller	Urban	0.4	1014.8	3.9 (4.56)	100.0
Earl Scott	Urban	0.9	646.7	0.2 (0.37)	100.0
Harvey	Urban	0.4	987.7	2.1 (1.48)	100.0
Houston-Harte	Urban	2.0	321.0	5.2 (5.76)	61.5
Huneke	Urban	1.4	440.1	6.5 (15.49)	95.8
Kennedale	Urban	1.3	419.4	1.4 (3.13)	100.0
Optimist	Urban	0.8	496.3	0.9 (0.69)	93.3
Russell Creek	Urban	2.8	249.4	0.0	
All Lakes		1.2 (0.7)	614.2 (293.4)	4.6 (10.7)	77.5 (28.7)
Urban Lakes		1.4 (0.8)	530.7 (273.2)	2.5 (6.0)	77.7 (29.4)
Rural Lakes		1.0 (0.5)	697.8 (302.7)	6.8 (13.9)	77.0 (23.9)

TABLE 5. —Name, type, surface area, channel catfish stocking rate, mean hoop-net catch-per-unit-effort (CPUE), and percentage of catfish caught in hoop nets that were stocked for 16 community fishing lakes in Texas from April – August, 2015.

Name	Type	April CPUE (fish/net-set)	June CPUE (fish/net-set)	August CPUE (fish/net-set)	Average CPUE (SD) (fish/net-set)
Abernathy	Rural	3.5	*	56.5	30.00 (37.5)
Atlanta	Rural	0	0	0	0.00 (--)
Davidson	Rural	27.5	1	11.5	13.33 (13.3)
Karrh	Rural	0.5	13.5	0	4.67 (7.6)
Knierim	Rural	26.5	0	1.5	9.33 (14.9)
Little Chocolate	Rural	2	0	0	0.67 (1.1)
Winchester	Rural	0	1.5	2	1.17 (1.0)
Bethany	Urban	0	1.5	1.5	1.00 (0.9)
Cal Young	Urban	0.67	3.67	1	1.78 (1.6)
Cy Miller	Urban	0	3.5	0.5	1.33 (1.9)
Harvey	Urban	0	1.5	5.5	2.33 (2.8)
Houston-Harte	Urban	5	1.5	0	2.17 (2.6)
Huneke	Urban	0.5	*	5.5	3.00 (3.5)
Kennedale	Urban	0	0	0	0.00 (--)
Optimist	Urban	6.5	0	0	2.17 (3.8)
Russell Creek	Urban	0	3	1	1.33 (1.5)
Average	All Lakes	4.54	2.19	5.41	4.64
	Urban Lakes	1.41	1.83	1.67	1.68
	Rural Lakes	8.57	2.67	10.21	8.45

*Flooding prevented sampling during this period.

TABLE 6. —Number, mean weekly angling effort (h), range of weekly angler effort (h), median weekly angler effort (h), and mean hoop-net catch-per-unit-effort (CPUE; fish/net-set) by stocking success category for 18 community fishing lakes in Texas from 14 October 2013 – 30 August 2014. Means with the same superscript were similar (post hoc Bonferroni (Dunn) t Tests for count data, $\underline{P} > 0.05$). Standard deviation is presented in parentheses.

Type	number	Mean angler effort	Angler effort range	Median angler effort	Mean hoop-net CPUE
Successful	9	15.8^{B} (11.5)	0-222	13.6	6.9 (12.7)
Partial success	4	30.6^{A} (22.3)	0-308	32.3	3.3 (9.2)
Unsuccessful	5	22.7^{AB} (15.8)	0-145	20.3	0.0

TABLE 7.—Success rating of study lakes based on hoop net catch rates over six months for lakes stocked in the fall of 2013 and the spring of 2015.

Name	Type	Fall rating	Spring rating	Rating change
Abernathy	Rural	Partial	Successful	+1
Davidson	Rural	Successful	Successful	0
Frio	Rural	Partial		
Lester	Rural	Successful		
Little Chocolate	Rural	Successful	Partial	-1
Winchester	Rural	Successful	Successful	0
Atlanta	Rural	Unsuccessful	Unsuccessful	0
Karrh	Rural	Unsuccessful	Partial	+1
Bridge Bob's	Rural	Unsuccessful		
Knierim	Rural	Unsuccessful	Successful	+2
Bethany	Urban	Successful	Successful	0
Cal Young	Urban	Successful	Successful	0
Cy Miller	Urban	Successful	Successful	0
Earl Scott	Urban	Partial		
Harvey	Urban	Successful	Successful	0
Houston-Harte	Urban	Successful	Partial	-1
Huneke	Urban	Partial	Successful	+1
Kennedale	Urban	Partial	Unsuccessful	-1
Optimist	Urban	Successful	Partial	-1
Russell Creek	Urban	Unsuccessful	Successful	+2

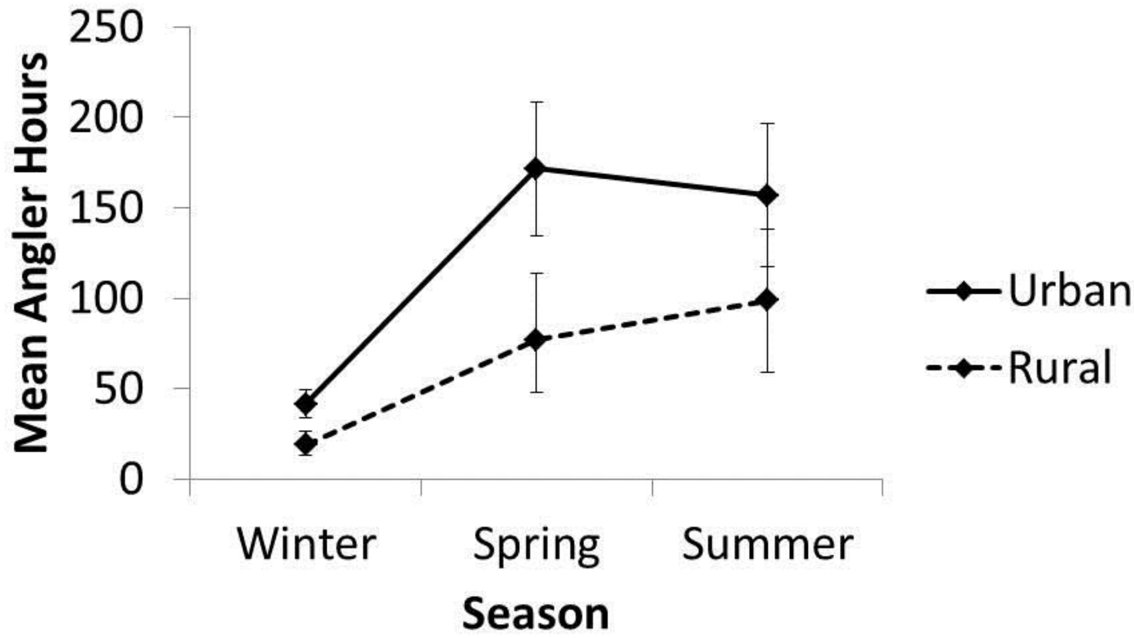

FIGURE 1.—Mean seasonal angler effort (angler-h) between urban and rural lakes stocked with marked channel catfish in Texas. Vertical bars indicate standard error.

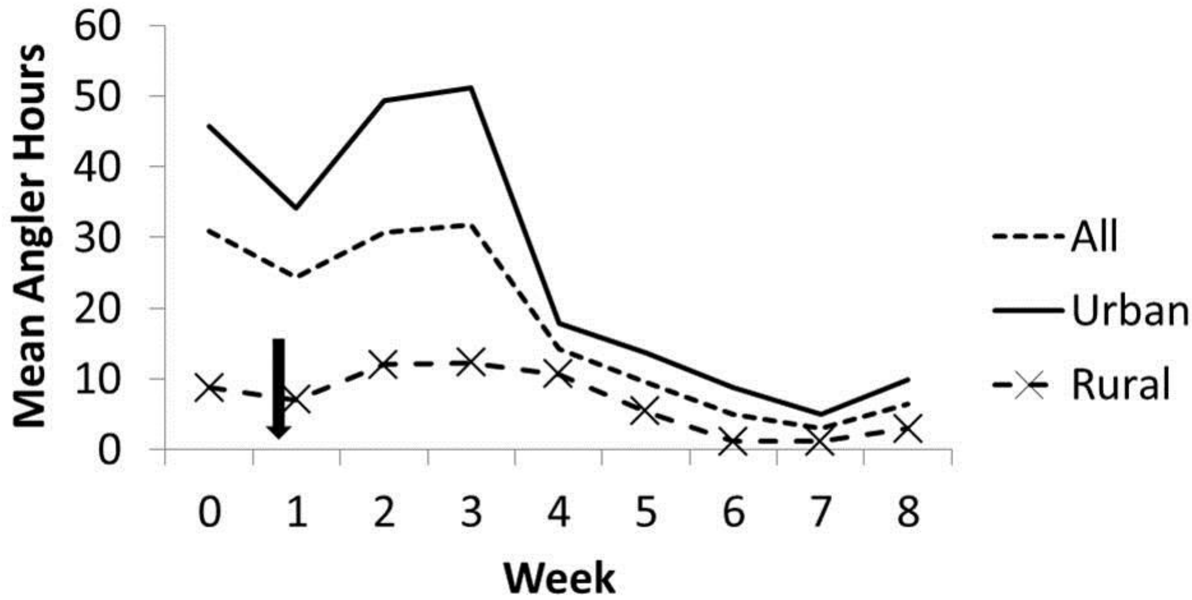

FIGURE 2.—Mean weekly angler effort (angler hours) for nine urban and nine rural lakes in Texas following stocking. Stocking was conducted during week one as indicated by the vertical arrow.

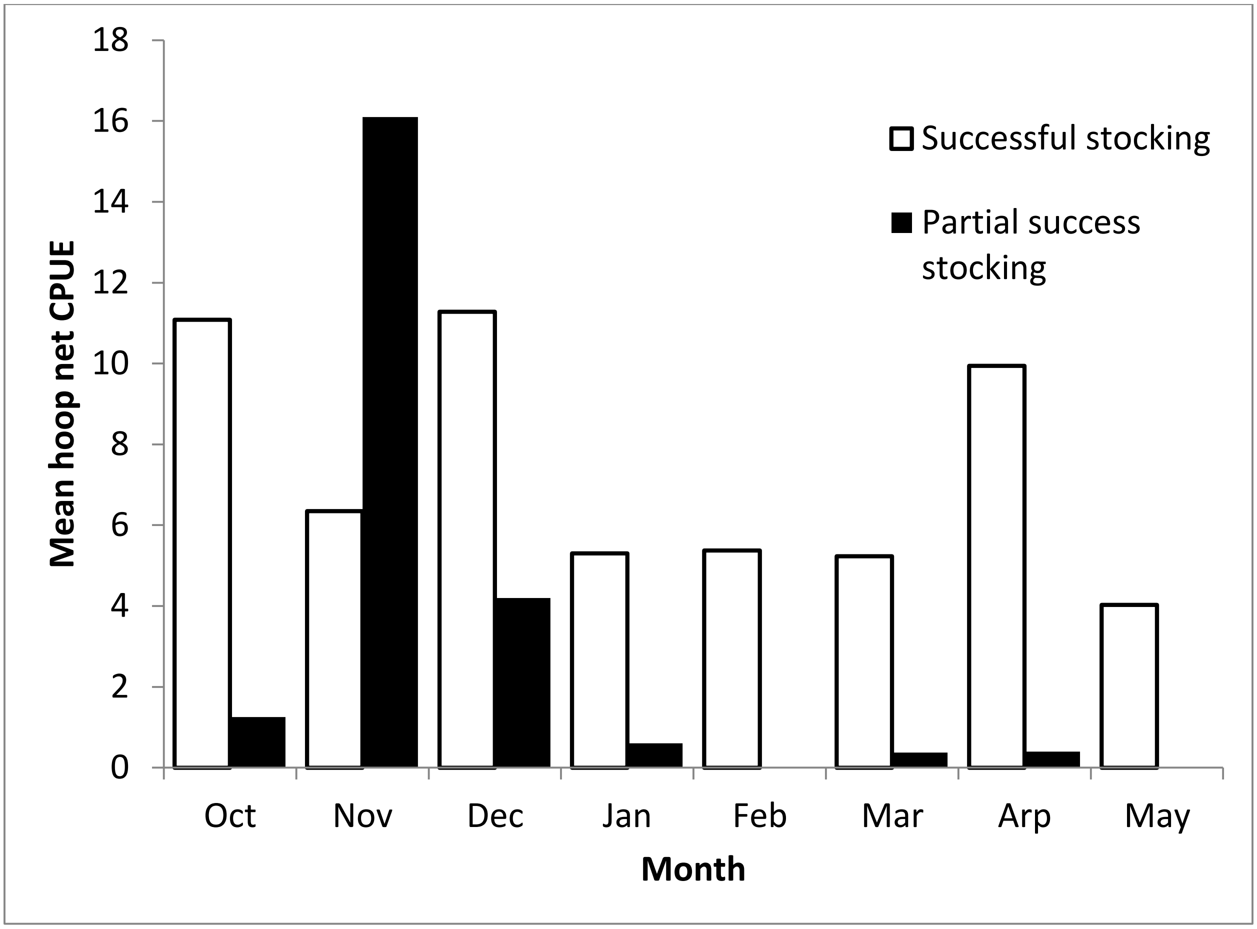

FIGURE 3.—Mean monthly hoop net CPUE (fish net-set^{-1}) for 10 lakes categorized as successfully stocked and five lakes categorized as partially successfully stocked with channel catfish in Texas community fishing lakes.

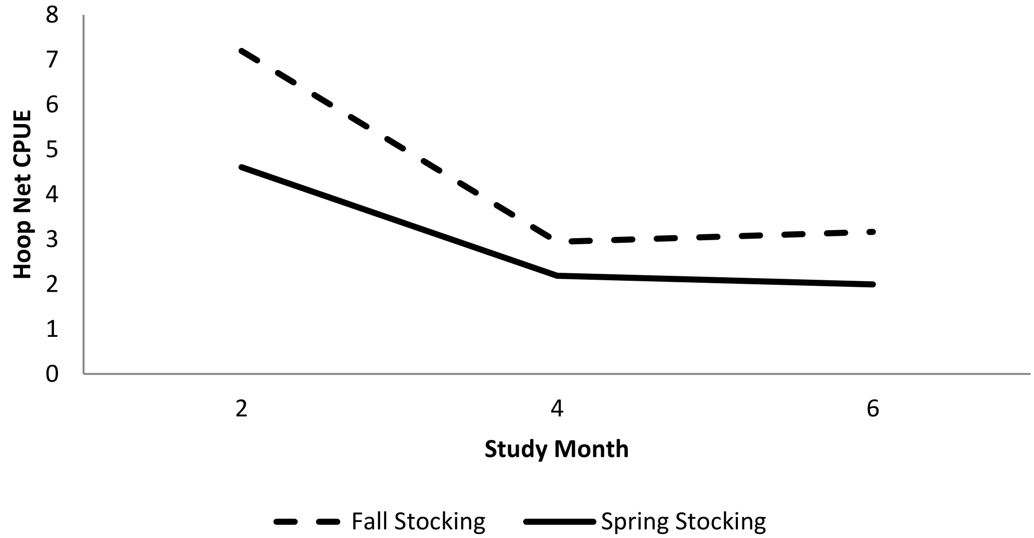

FIGURE 4.—Spring and fall hoop net catch rates over time for channel catfish stocked in the fall of 2013 and the spring of 2015. Graph excludes data from one lake deemed to be an outlier.

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